What Happened to the Swordfish?

For use with Fish Watch at www.fishwatch.gov

Grade Level
9-12

Materials
- Copies of Student Worksheet
- Copies of Student Handout – The Pelagic Longline Fishery
- Computers for pairs of students with Internet access for graphing (or graph paper if no internet is available)
- Graph paper (optional)

Audio/Visual Materials
- Projector to show videos
- Computers with Internet access

Teaching Time
Two to Three 45-minute class periods

Seating Arrangement
Students sitting in pairs

Key Words
- Annual landings
- Overfishing
- Overfished
- Pelagic
- Non-target

Focus
Swordfish populations and the factors that influence them

Focus Questions
What trends were seen in the swordfish fishery over the last two decades?
What is longlining and how does it impact fisheries?

Learning Objectives
- Analyze and draw conclusions from annual landings data
- Explain the difference between overfishing and overfished
- Describe the fishing method of longlining

Background Information
Overfishing versus Overfished
Overfishing occurs when the rate of removal from a fish stock is too high. It would be natural to assume that overfishing and overfished have the same

National Science Education Standards

Grades 9-12

Content Standard C: Life Science

- Interdependence of organisms

Content Standard F: Science in Personal and Social Perspectives

- Natural resources
- Science and Technology in Local, National and Global Challenges

Ocean Literacy Essential Principles

Essential Principle 1

The earth has one big ocean with many features.

Fundamental Concept h

Although the ocean is large, it is finite and resources are limited.

Essential Principle 6

The ocean and humans are inextricably connected.

Fundamental Concept b

From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.

Fundamental Concept e

Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

causes, but they may not. A stock is deemed "overfished" when its population is too low, or below a prescribed threshold. A population can be overfished but be managed under a rebuilding plan that over time returns the population to optimal levels. Reasons that a fish stock becomes overfished can include environmental changes, natural mortality, disease and natural population cycles.

Environmental changes play a large role in what happens to a fish stock in our waters. A fish's environment (habitat) includes physical factors, such as temperature and bottom type, as well as chemical factors, such as oxygen levels and dissolved minerals. The habitat needs for each stage of a fish's life cycle—egg, larvae, juvenile, and adult—vary within the same water body. So changes in these environmental factors can greatly affect the population of a stock.

Pacific Swordfish

Prized for its flavorful, steak-like meat, swordfish is found and harvested in temperate and tropical oceans around the world. U.S. fishermen responsibly harvest swordfish in both the Atlantic and Pacific Oceans. In the Pacific, most of the harvest comes from fisheries off California and Hawaii. All U.S. fisheries for swordfish are strictly managed, both to conserve the swordfish resource and minimize the fisheries' impact on other species.

For example, the Hawaii-based shallow-set longline fishery that targets swordfish operates under strict regulations to protect sea turtles, seabirds, and marine mammals. Most of these regulations were developed after years of research assessing the environmental impacts of longline fishing for swordfish off the Hawaiian Islands in the North Pacific. Fishermen use large circle hooks and finfish bait to reduce catch of sea turtles, and are trained in sea turtle handling and release techniques to increase the survival rate of any turtles that are incidentally caught. Each fishing vessel carries observers to record catch and interactions with protected species such as sea turtles, and satellite tracking systems are used to monitor fishing. There is also an annual limit on the number of sea turtles that can be hooked or entangled; if the limit is reached, the fishery is closed for the rest of the year. Research has shown that these sea turtle protections are working, and most interactions between the fishing fleet and loggerhead and leatherback sea turtles are non-lethal.

Atlantic Swordfish

In the late 1990s, the North Atlantic swordfish population was low, at only 58 percent of its target level, and was declared overfished. Pelagic longlines, which are the primary commercial gear used to catch swordfish, were also catching endangered sea turtles. Fast forward 10 or so years and this same population of swordfish is thriving and interactions between pelagic longlines and sea turtles have been reduced by 90 percent. What happened over this decade to change the fate of the swordfish fishery in the North Atlantic?

Under an international rebuilding plan for swordfish, the United States implemented a number of management measures to reduce the amount of fishing and to protect undersized swordfish, to allow the swordfish population to grow and rebuild. Fishermen, managers, and scientists worked together to develop new management measures that reduce the impact the U.S. fishery has on sea turtles and marine animals, making it one of the most environmentally responsible pelagic longline fisheries in the world. Most people are not aware

Essential Principle 7
The ocean is largely unexplored.

Fundamental Concept c
Over the last 40 years, use of ocean resources has increased significantly; therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations

on sea turtles and marine animals, making it one of the most environmentally responsible pelagic longline fisheries in the world. Most people are not aware of the significant sacrifices made by U.S. Atlantic swordfish fishermen to rebuild North Atlantic swordfish. Swordfish is one of the great success stories of fishery management.

Sources:

- www.fishwatch.gov
- www.fishwatch.gov/features/overfishing_overfished_same_thing.htm
- www.nmfs.noaa.gov/stories/2011/07/14_overfished_isnt_just_about_fishing.html

Learning Procedure

1. Ask students if they or their families have eaten swordfish, and let them tell the class about their experiences. To introduce students to swordfishing and longlining, share the background information for this lesson with them and show images of these topics from Fish Watch website: www.fishwatch.gov/seafood_profiles/species/swordfish/group_pages/index.htm The Overview sections for both the North Atlantic and Pacific swordfish contain image galleries.

2. Hand out the Student Worksheet and Student Handout. Define annual landings; be sure that students understand that landings are the report of the total number or weight of all marine species captured, brought to shore, and sold (or transferred) to another person or party. Landings are not the same as catch. Catch is a measure of all marine species removed from the marine environment, including bycatch, fish released, at sea discards and species not sold. Landings are anything received from a harvester regardless of whether it is discarded or not sold. Landings do not include all of the organisms that are released and/or discarded at sea.

3. Instruct students to create a line graph of their data. This can be done online at: nces.ed.gov/nceskids/createagraph/default.aspx or students may use graph paper. Remind them that the database tracks all species of swordfish, so this includes North Atlantic swordfish and Pacific swordfish. They will not be able to distinguish between individual swordfish species in this data.

4. They should then answer the questions posed on the Student Worksheet.

5. Discuss students' answers from their worksheets, and ask what they think happened to the swordfish. Then lead the class in a discussion of broader questions, and encourage students to think about these questions from a number of perspectives (fisheries manager, local restaurant owner, consumer, etc.)

- What are some of the ways that changes in technology might have changed the fishing industry?
- What are some of the ways that these changes might have changed the populations of swordfish and other fish/shellfish?
- What might happen if annual landings are taken and stocks aren't monitored?
- How might this affect our oceans in the future?
- Why is it important to take interest in the health of our fisheries?
- Are swordfish considered overfished? Are they sustainable?

6. As a class, watch the 5-minute video clip about longlining from the Pew Environment Group called "Switching Gears: Longlining in the Gulf of Mexico" at www.pewenvironment.org/news-room/video-library/switching-gears-surface-longlining-in-the-gulf-of-mexico-8589942571. After watching this clip, ask students if/how they might modify their answers to Question #8 on the worksheet.

The Bridge Connection

www.vims.edu/bridge
Use the search function to search for "fisheries" to access lesson plans and many additional resources.

The "Me" Connection

Ask students if they or anyone in their family participates in recreational or commercial fishing. Discuss how overfishing could impact them personally, whether they are fishermen or they buy and consume fish.

Connections to Other Subjects

Mathematics, Language Arts, Environmental Policy

Evaluation

Assessment could include students' data analysis, their graphing of the data, worksheet answers, and participation in class discussions.

Extension

Students should understand the difference between overfished and overfishing, and why it's okay to eat an overfished fish/shellfish. To demonstrate their understanding, students can design an advertisement or commercial for a sustainably caught fish/shellfish described on www.fishwatch.gov.

Additional Resources

- Atlantic swordfish species information
  www.nmfs.noaa.gov/sfa/hms/hmsdocument_files/SWORDFISH.htm%20
- FAO Fishing Gear Fact Sheets:
  www.fao.org/fishery/geartype/search/en
- Surprising Swordfish Assessment Leads To More Fishing Opportunities
  www.magazine.noaa.gov/stories/mag68.htm
- New Fishing Hooks Protect Bluefin Tuna in Gulf of Mexico
  www.nmfs.noaa.gov/stories/2011/04/hooks_protect_blufin_tuna_in_gulf_of_mexico.htm
- NOAA Report on Swordfish
  www.noaanews.noaa.gov/stories2010/20100510_swordfish.html
- "Overfished" Isn't Just About Fishing
  www.nmfs.noaa.gov/stories/2011/07/14_overfished_isnt_just_about_fishing.html

Teacher Answer Sheet

NMFS Landings Query Results

- Year : From: 1990 To: 2010
- Species : swordfish
- State : All States

Year	Species	Metric Tons	Pounds	$
1990	SWORDFISH	6,992.7	15,416,065	44,681,217
1991	SWORDFISH	8,582.8	18,921,644	51,182,139
1992	SWORDFISH	9,646.6	21,267,004	59,853,496
1993	SWORDFISH	10,848.2	23,915,834	55,186,940
1994	SWORDFISH	7,403.9	16,322,541	42,486,408
1995	SWORDFISH	6,267.3	13,816,799	35,480,755
1996	SWORDFISH	6,107.2	13,463,987	35,377,661
1997	SWORDFISH	6,510.1	14,352,208	33,530,389
1998	SWORDFISH	6,854.0	15,110,321	28,817,806
1999	SWORDFISH	7,466.6	16,460,947	33,694,978
2000	SWORDFISH	8,011.1	17,661,210	37,913,267
2001	SWORDFISH	4,266.2	9,405,323	19,839,064
2002	SWORDFISH	3,941.2	8,688,817	16,986,429
2003	SWORDFISH	4,142.1	9,131,702	18,100,403
2004	SWORDFISH	2,741.7	6,044,363	13,701,362
2005	SWORDFISH	3,021.7	6,661,740	16,365,384
2006	SWORDFISH	2,711.1	5,976,978	13,460,982
2007	SWORDFISH	3,668.9	8,088,465	20,115,544
2008	SWORDFISH	3,612.4	7,963,975	17,309,389
2009	SWORDFISH	4,025.5	8,874,527	19,504,724
2010	SWORDFISH	3,521.0	7,762,318	21,818,600
GRAND TOTALS:	-	120,342.4	265,306,768	635,406,937

Student Handout
The Pelagic Longline Fishery

The U.S. pelagic longline fishery for Atlantic Highly Migratory Species (HMS) primarily targets swordfish, yellowfin tuna, or bigeye tuna in various areas and seasons. Secondary target species include dolphin; albacore tuna; pelagic sharks including mako, thresher, and porbeagle sharks; as well as several species of large coastal sharks. Although this gear can be modified (i.e., depth of set, hook type, etc.) to target swordfish, tunas, or sharks, it is generally a multi-species fishery. These vessel operators are opportunistic, switching gear style and making subtle changes to target the best available economic opportunity of each individual trip. Longline gear sometimes attracts and hooks non-target finfish with no commercial value, as well as species that cannot be retained by commercial fishermen due to regulations, such as billfish. Pelagic longlines may also interact with protected species such as marine mammals, sea turtles, and seabirds. Thus, this gear has been classified as a Category I fishery with respect to the Marine Mammal Protection Act. Any species (or undersized catch of permitted species) that cannot be landed due to fishery regulations is required to be released, whether dead or alive.

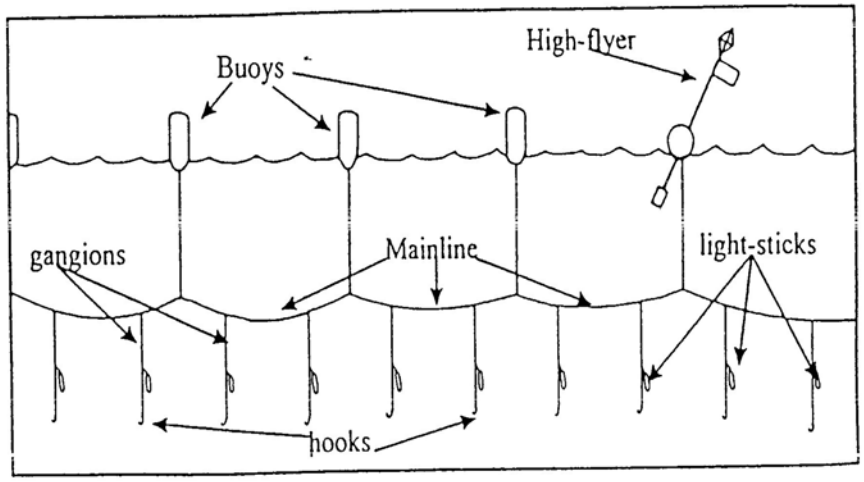

Figure 1. Typical U.S. pelagic longline gear. Source: Arocha 1996

Pelagic longline gear is composed of several parts (see Figure 1). The primary fishing line, or mainline of the longline system, can vary from five to 40 miles in length, with approximately 20 to 30 hooks per mile. The depth of the mainline is determined by ocean currents and the length of the floatline, which connects the mainline to several buoys and periodic markers which can have radar reflectors or radio beacons attached. Each individual hook is connected by a leader to the mainline. Lightsticks, which contain chemicals that emit a glowing light are often used, particularly when targeting swordfish. When attached to the hook and suspended at a certain depth, lightsticks attract bait fish which may, in turn, attract pelagic predators.

When targeting swordfish, the lines generally are deployed at sunset and hauled at sunrise to take advantage of swordfish nocturnal near-surface feeding habits. In general, longlines targeting tunas are set in the morning, deeper in the water column, and hauled in the evening. Except for vessels of the distant water fleet which undertake extended trips, fishing vessels preferentially target swordfish during periods when the moon is full to take advantage of increased densities of

pelagic species near the surface. The number of hooks per set varies with line configuration and target catch

Figure 2 illustrates the difference between swordfish (shallow) sets and tuna (deep) longline sets. Swordfish sets are buoyed to the surface, have few hooks between floats, and are relatively shallow. This same type of gear arrangement is used for mixed target sets. Tuna sets use a different type of float placed much further apart. Compared with swordfish sets, tuna sets have more hooks between the floats and the hooks are set much deeper in the water column. It is believed that because of the difference in fishing depth, tuna sets hook less turtles than the swordfish sets. The hook types are also different for each target species. Swordfish sets generally use "J" hooks and tuna sets use "tuna" hooks, which are more curved than "J" hooks. In addition, tuna sets use bait only, while swordfish fishing uses a combination of bait and lightsticks. Compared with vessels targeting swordfish or mixed species, vessels targeting tuna typically are smaller and fish different grounds.

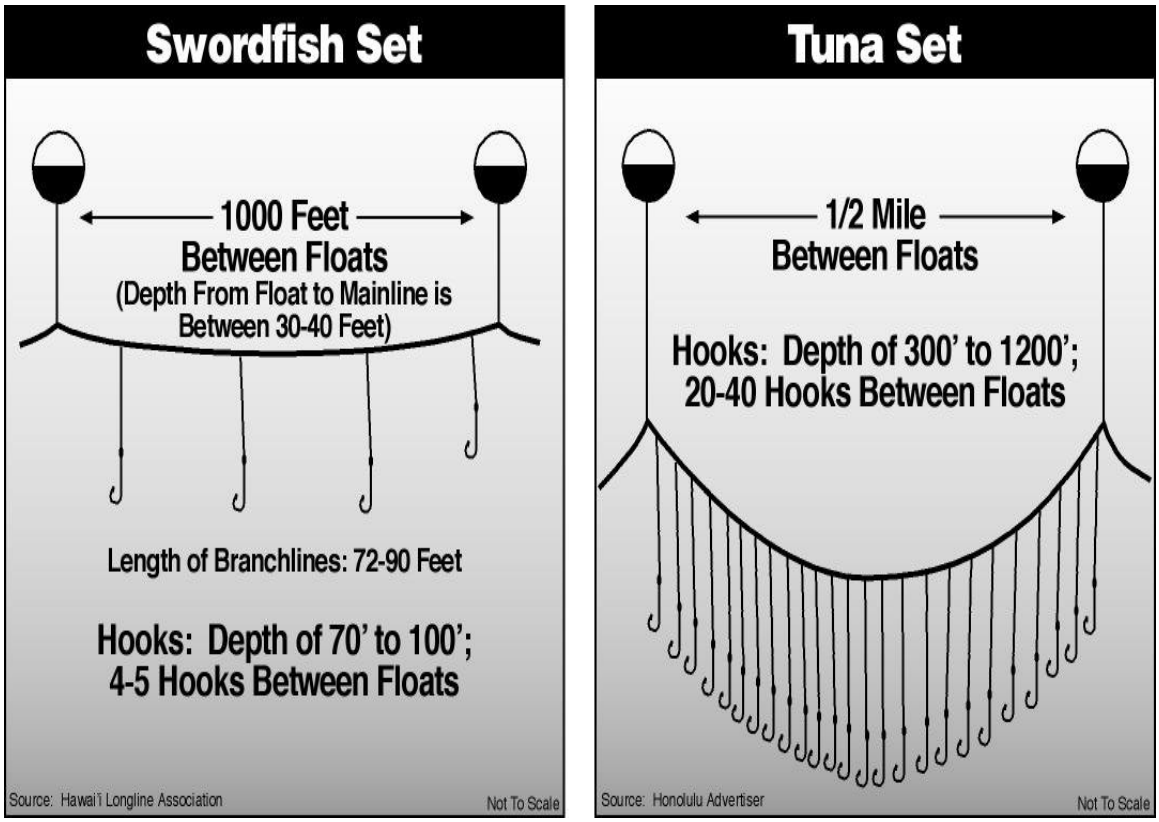

Figure 2. Different longline gear deployment techniques. Source Hawaii Longline Association and Honolulu Advertiser

Source: 2011 Stock Assessment and Fishery Evaluation (SAFE) Report for Atlantic Highly Migratory Species, www.fishwatch.gov

Student Worksheet

Write your answers on a separate sheet of paper.

1. Visit the National Marine Fisheries Service's Annual Landings Query Database at http://www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html

2. In the Species box:
   Type swordfish
   Under Year Range, choose 1990 to 2010
   Leave Geographic Area as "All States"
   Leave Output Form as "Table"
   Click on Submit Query, and your data should appear as a table
   Print out the table

3. Create a line graph of your table, and be sure to label the x- and y-axis appropriately.

4. What trends do you notice in your graph? What are some possible reasons for these trends?

5. Refer to the information in the handout on longline fishing. How is this fishing technique adaptable, depending on the species being fished?

6. Use the www.fishwatch.gov web site to compare the fishing rate, habitat impacts, bycatch, and population status of the Atlantic swordfish and the Pacific swordfish.

7. Are these species currently considered to be overfished? Why or why not?

8. If you were a fishery manager, what recommendations would you have for sustaining the swordfish populations? How might your recommendations change if you were a swordfish fisherman or seafood market owner?